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(54) **POWERED ORAL CARE IMPLEMENT**

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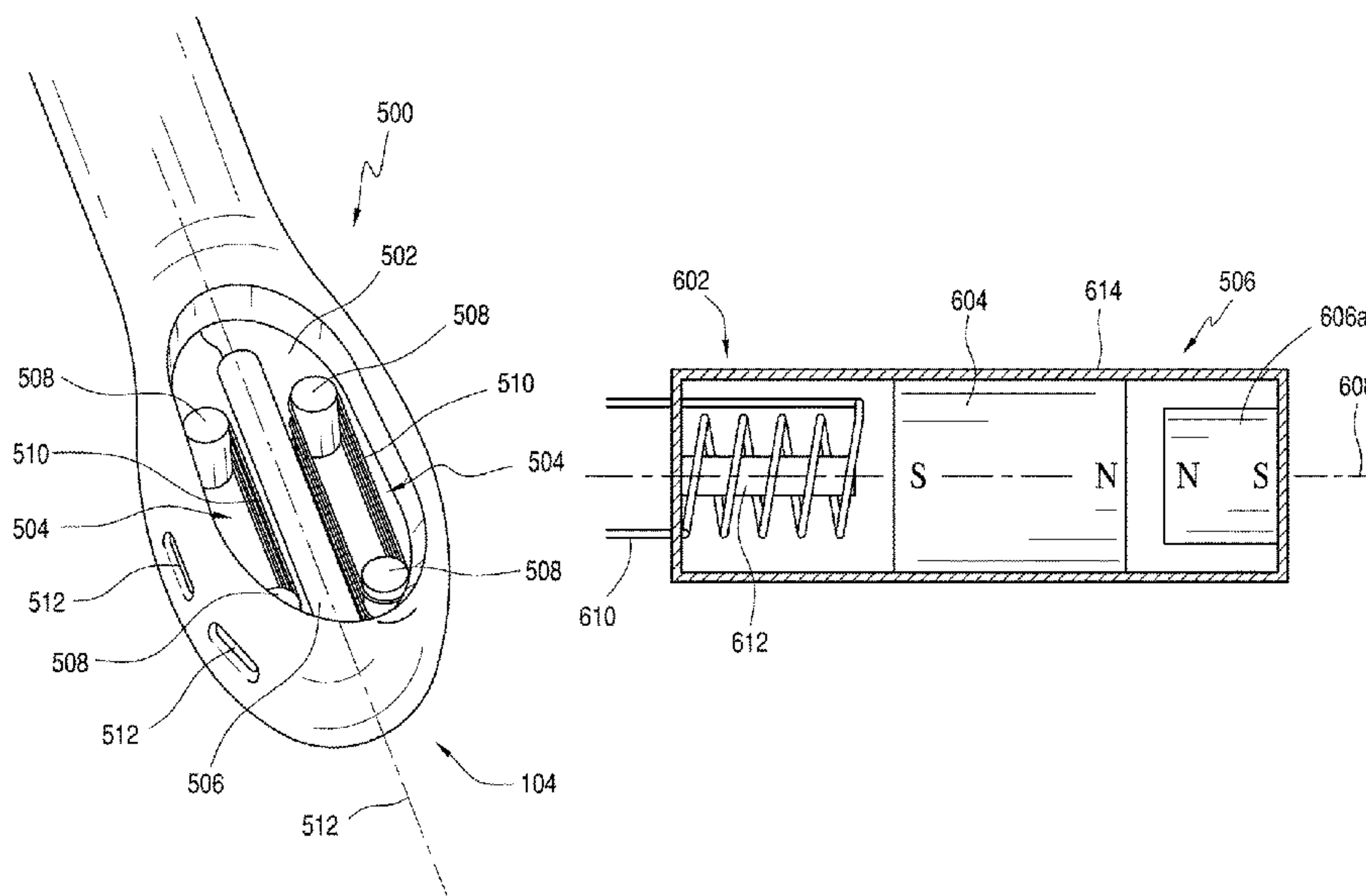
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*Primary Examiner* — Randall E Chin

(57) **ABSTRACT**

A powered toothbrush includes a handle, a power source disposed in the handle, a head including a cavity disposed at a distal end of the handle, an electrically conducting element disposed in the cavity and electrically connected to the power source, and a movable cleaning element connected to the head and movable relative to the cavity. The movable cleaning element includes a tooth cleaning support member, a tooth cleaning element mounted on the support member, and a ferromagnetic member. Application of an electrical current to the electrically conducting element generates a magnetic field at the electrically conducting element. The magnetic field selectively at least one of attracts and repels the ferromagnetic member to move the movable cleaning element relative to the electrically conducting element.

**7 Claims, 5 Drawing Sheets**



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continuation of application No. 14/977,151, filed on Dec. 21, 2015, now Pat. No. 10,390,917.

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*C25B 1/26* (2006.01)  
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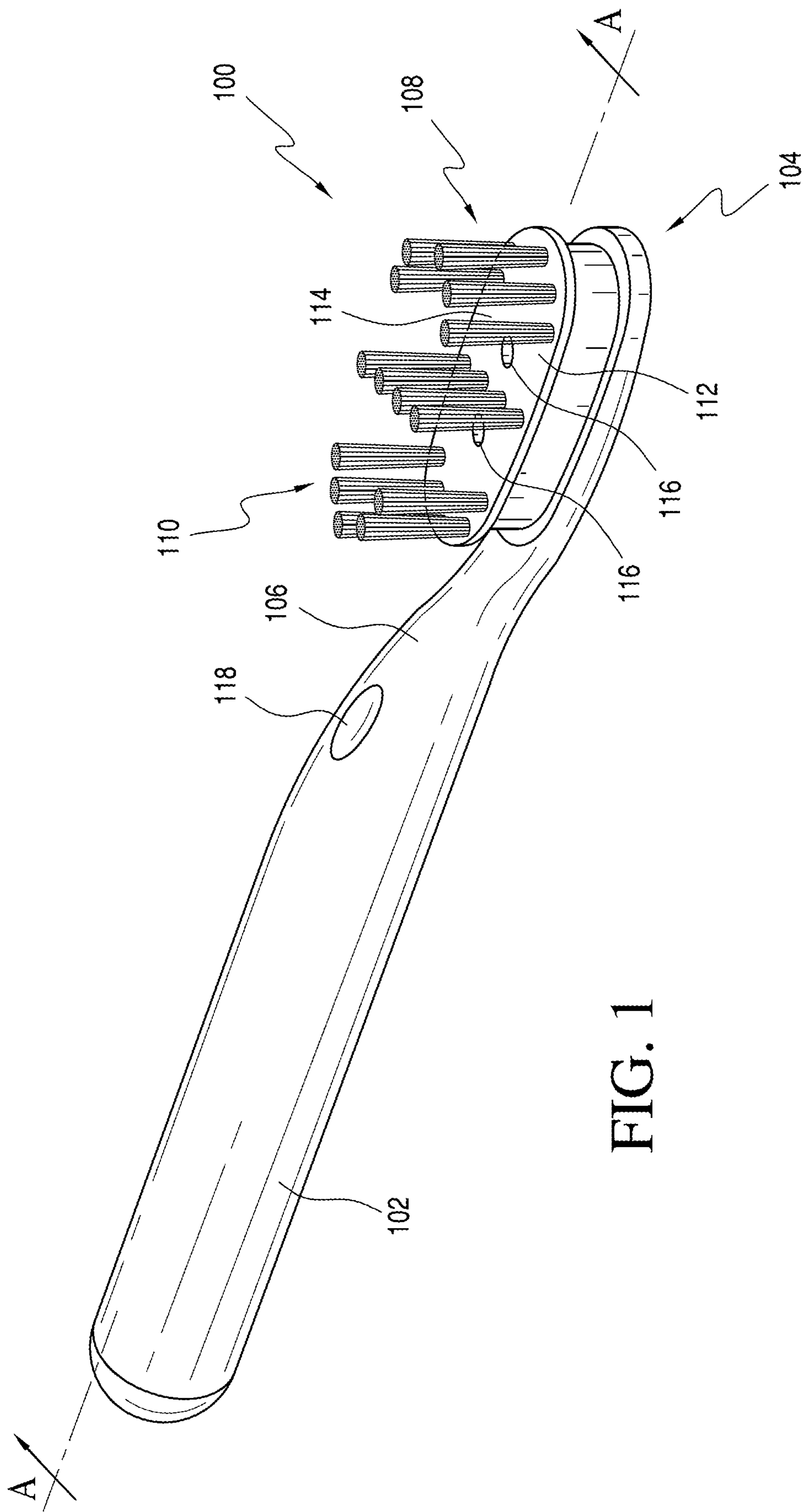


FIG. 1

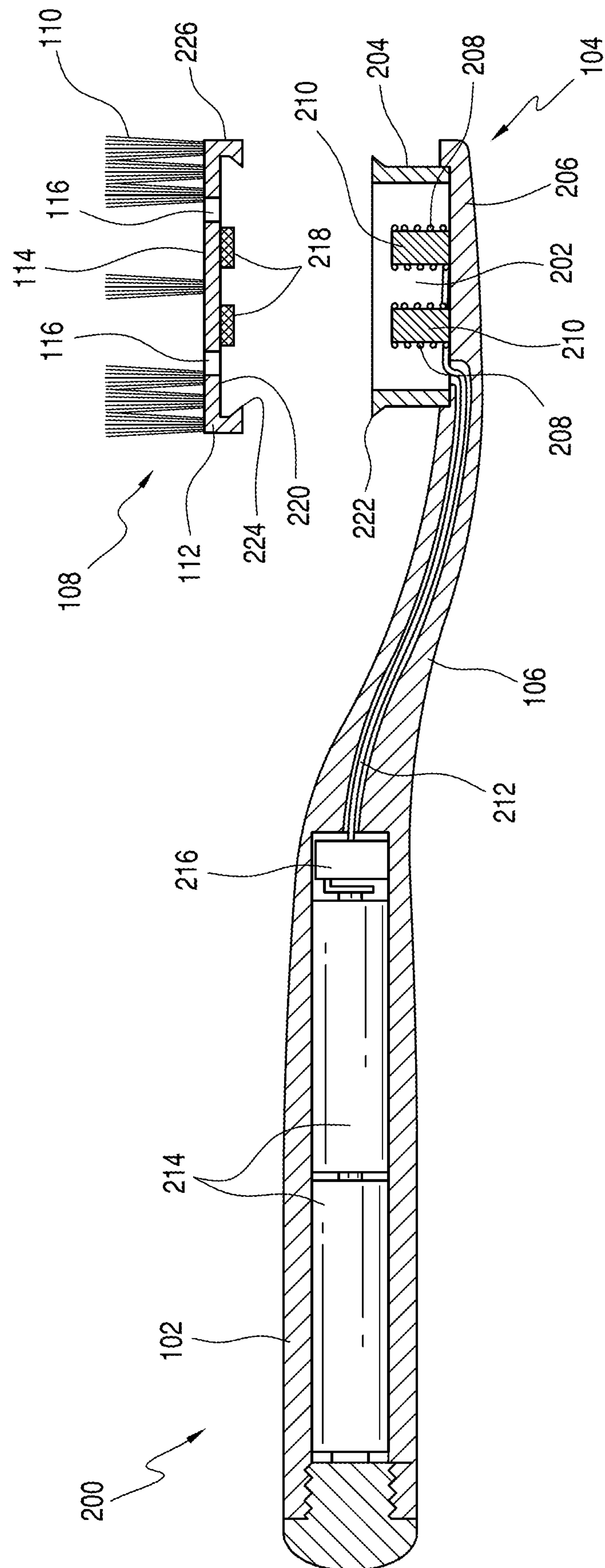


FIG. 2



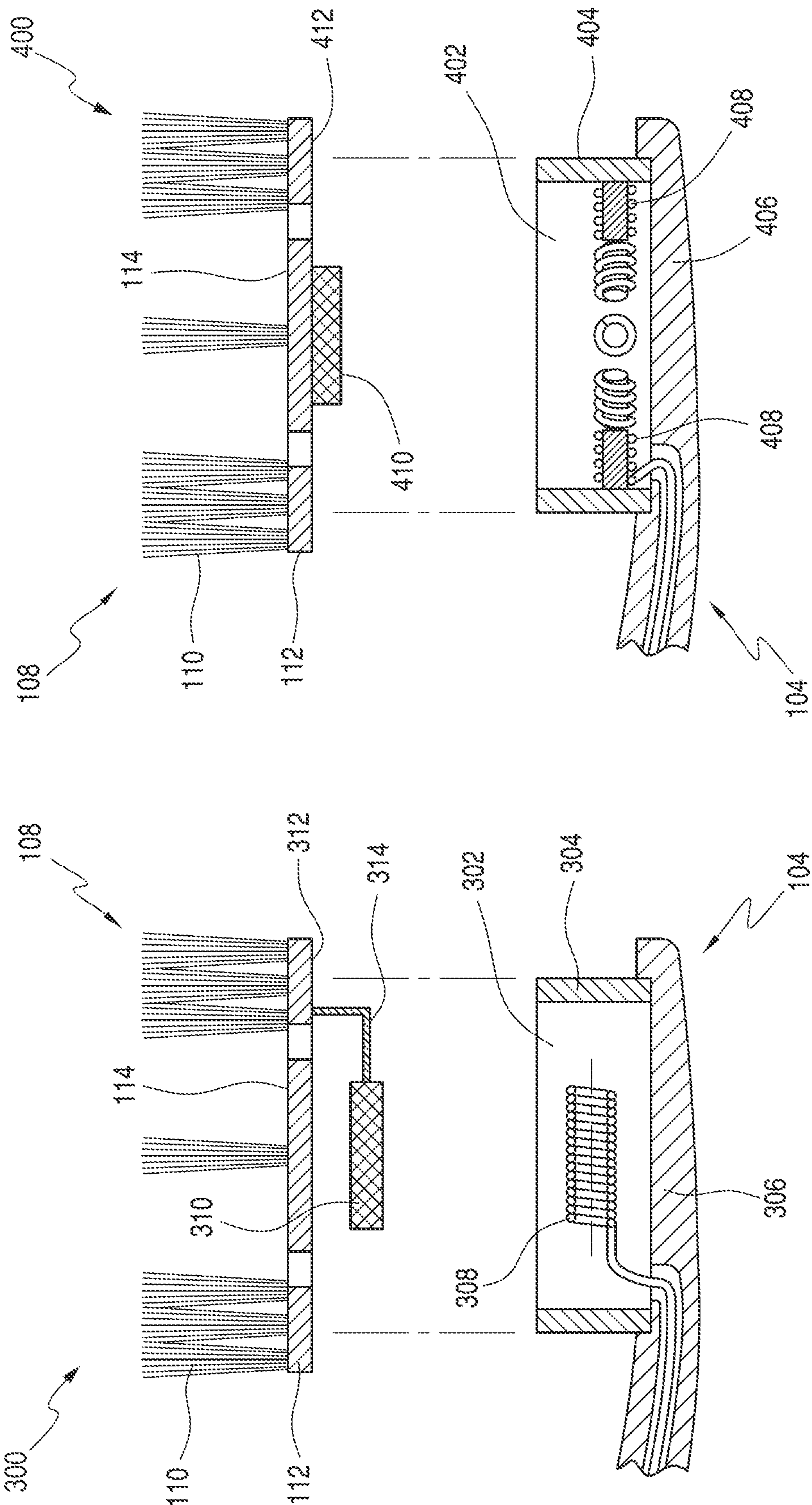


FIG. 3

FIG. 4A

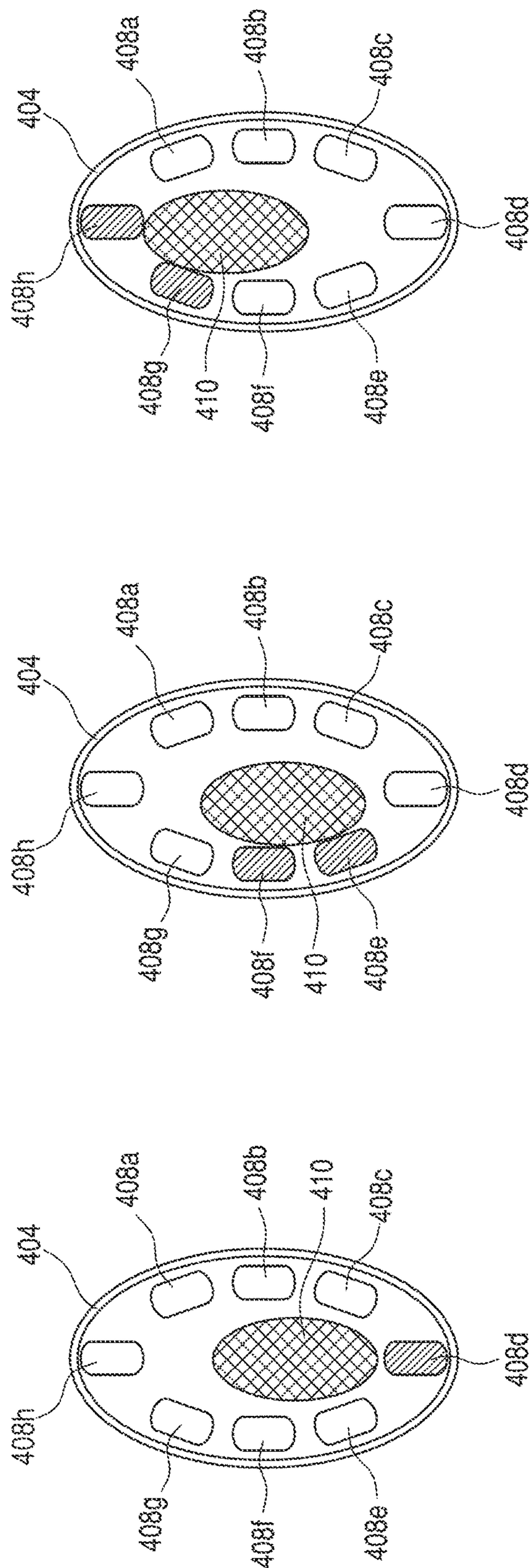


FIG. 4B

FIG. 4C

FIG. 4D

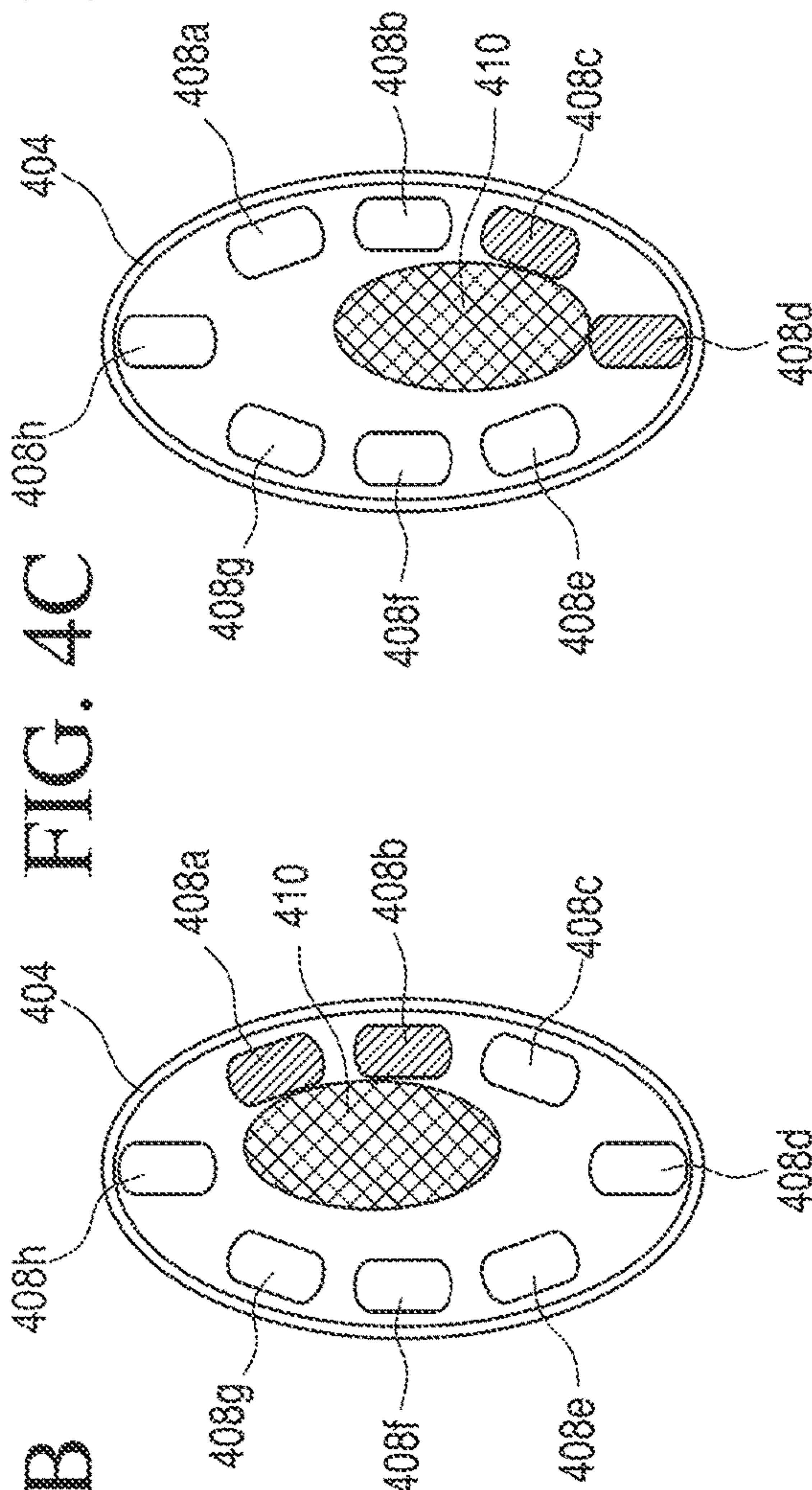


FIG. 4E

FIG. 4F



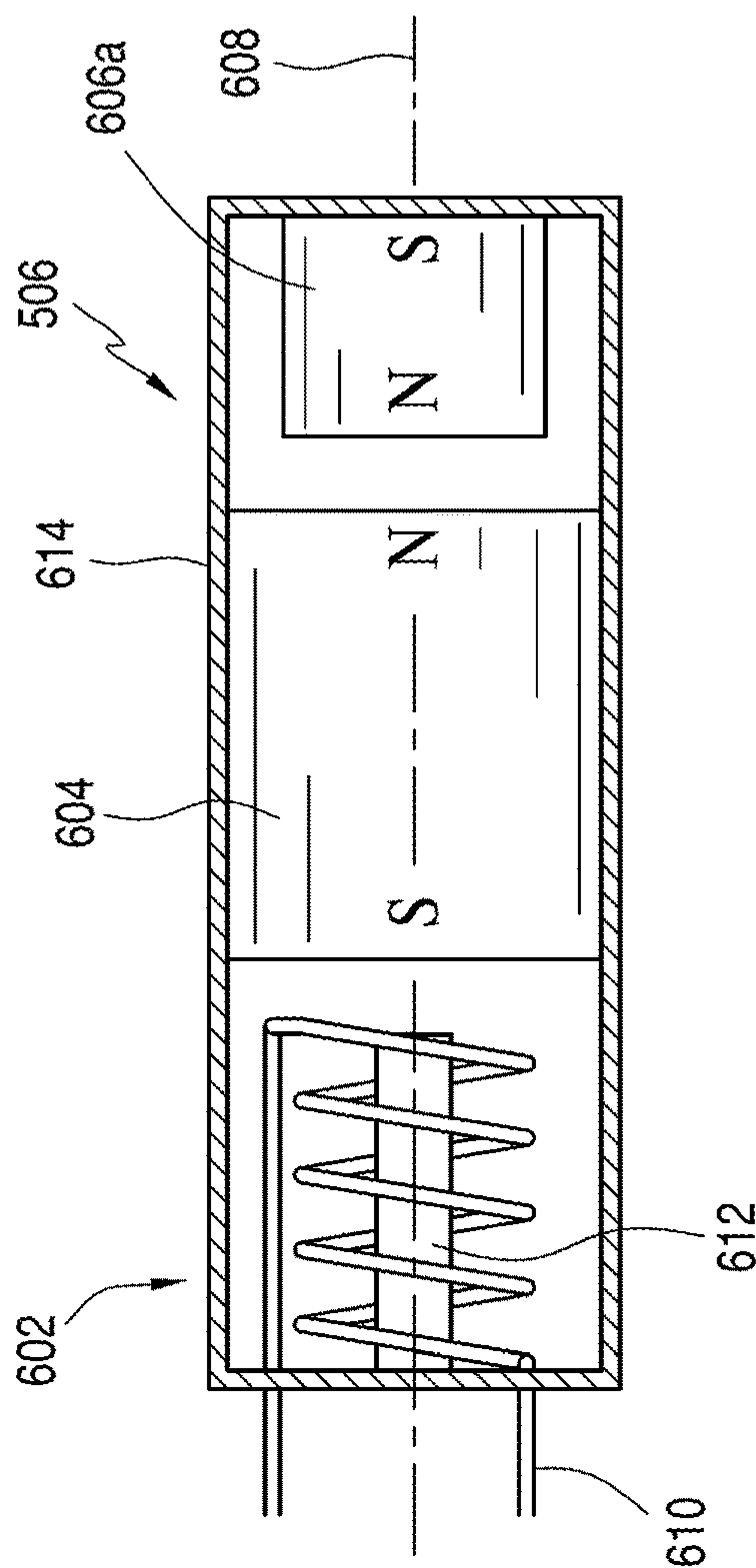


FIG. 6A

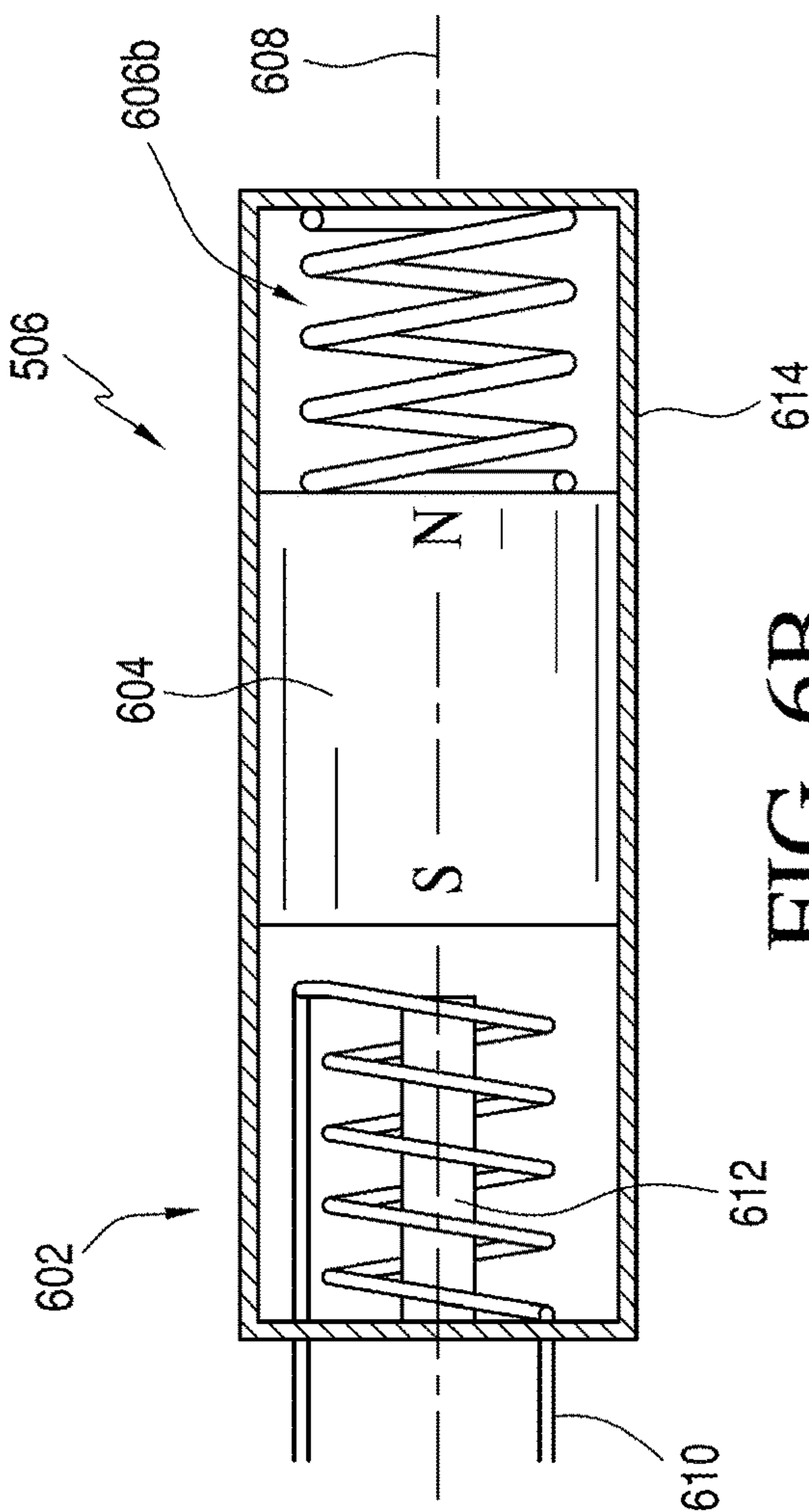


FIG. 6B

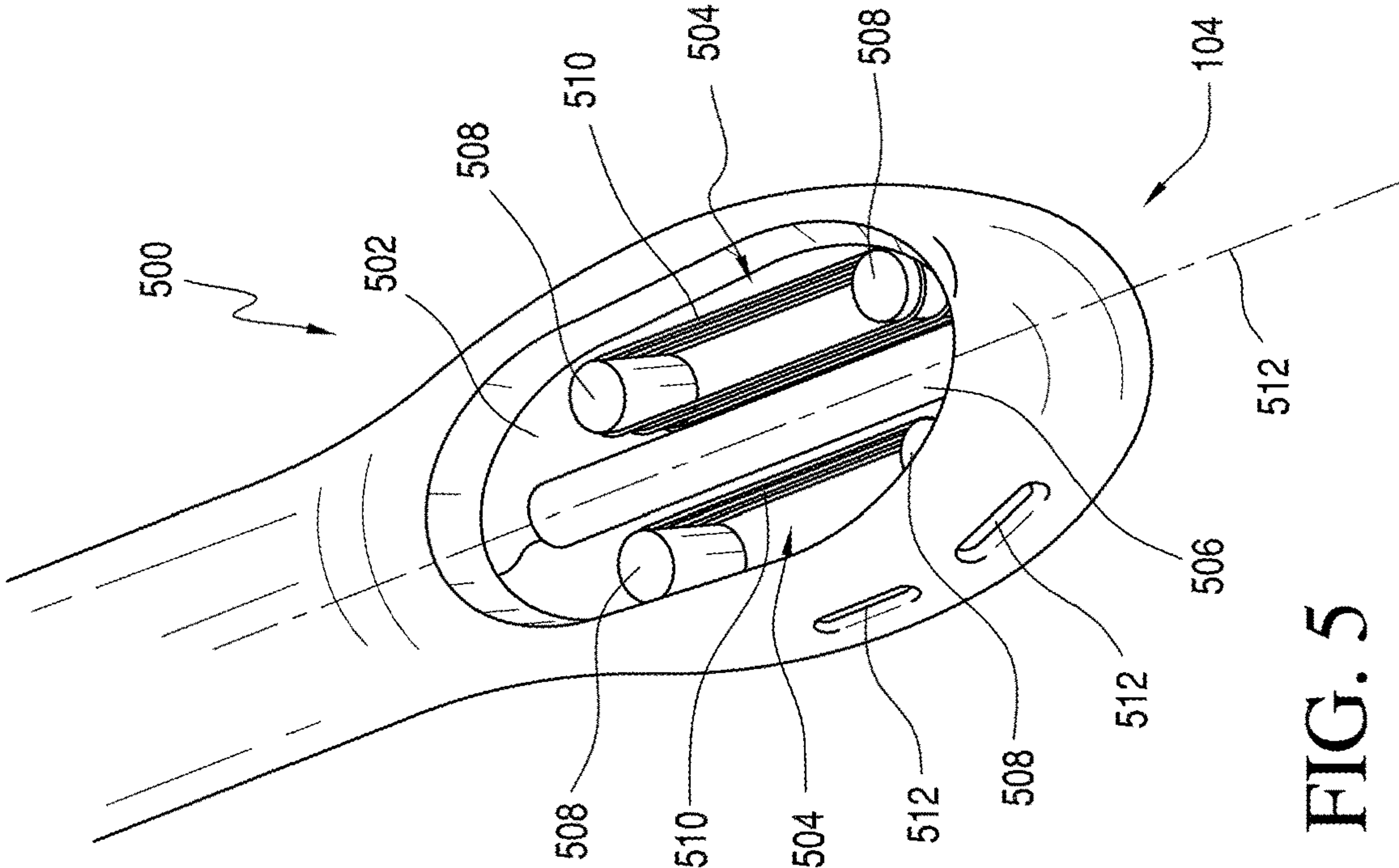


FIG. 5



**POWERED ORAL CARE IMPLEMENT****CROSS-REFERENCE TO RELATED APPLICATIONS**

This application is a divisional of U.S. patent application Ser. No. 16/508,395, filed Jul. 11, 2019, now U.S. Pat. No. 11,065,091, which is a continuation of U.S. patent application Ser. No. 14/977,151, filed on Dec. 21, 2015, now U.S. Pat. No. 10,390,917, which claims the priority benefit of U.S. Provisional Patent Application Ser. No. 62/096,574, filed Dec. 24, 2014, the entireties of which are hereby incorporated by reference.

**BACKGROUND**

Various powered oral care implements, such as powered toothbrushes, are conventionally known. Several such conventional toothbrushes house a motor or other actuator in the handle and transmit movement generated by the motor to a cleaning element at a head of the toothbrush. One conventional method for transmitting motion generated by the motor is via a driveshaft extending from the handle, through a neck of the toothbrush, to the cleaning element at the head. In these conventional devices, the brushing pattern is often limited by the design of the driveshaft. Moreover, in conventional toothbrushes of this sort, the electronics are contained completely within the handle, relatively far from the oral cavity.

Accordingly, there is a need in the art for an oral care implement in which the tooth cleaning elements are directly driven at the head of the implement.

Moreover, there is a need in the art for an oral care implement that can provide an electrical field in the head of the toothbrush, which may be used to promote oral health from within the oral cavity.

**BRIEF SUMMARY**

In aspects of this disclosure, a powered toothbrush includes a handle, a power source, a head including a cavity disposed at a distal end of the handle, an electrically conducting element disposed in the cavity and electrically connected to the power source, and a movable cleaning element connected to the head and movable relative to the cavity. The movable cleaning element includes a bristle support member disposed at least partially over the cavity, a plurality of bristles extending from the bristle support in a direction away from the cavity, and a ferromagnetic member. Application of an electrical current to the electrically conducting element generates a magnetic field at the electrically conducting element. The magnetic field selectively at least one of attracts and repels the ferromagnetic member to move the movable cleaning element relative to the electrically conducting element.

In one or more additional aspects, in a toothbrush as described in the preceding paragraph, the electrically conducting element comprises an electrode.

In one or more additional aspects, in a toothbrush as described in any of the preceding paragraphs, the electrically conducting element comprises an electrical coil disposed about a ferromagnetic member.

In one or more additional aspects, in a toothbrush as described in any of the preceding paragraphs, the bristle support member and the cavity define a volume and one or more of the electrically conducting element and the ferromagnetic member are disposed in the volume.

In one or more additional aspects, in a toothbrush as described in the preceding paragraph, a channel may extend between the volume and an exterior of the head.

In one or more additional aspects, in a toothbrush as described in any of the preceding paragraphs, a dentifrice slurry may be provided in the cavity.

In an additional aspect of this disclosure, a powered oral care implement includes a housing including a cavity, one or more electrically conducting elements disposed in the cavity, a power source electrically connected to each of the one or more electrodes, and a cleaning element disposed on the head to at least partially cover the cavity. Applying a current to individual of the one or more electrically conducting elements generates a field at the individual of the electrically conducting elements.

In one or more additional aspects, in an oral care implement as described in the preceding paragraph, the field at the individual of the electrically conducting elements is a magnetic field, and a ferromagnetic member is at least one of selectively attracted to and repelled by the magnetic field.

In one or more additional aspects, in an oral care implement as described in the preceding paragraph, the ferromagnetic member is fixed to the cleaning element and the cleaning element is configured to move relative to the one or more electrically conducting elements.

In one or more additional aspects, in an oral care implement as described in any of the preceding paragraphs, a dentifrice slurry is provided in the cavity.

In one or more additional aspects, in an oral care implement as described in the preceding paragraph, the one or more electrically conducting elements comprise one or more electrodes and the dentifrice slurry comprises one or more precursors converted by the electrodes to active species.

In one or more additional aspects, in an oral care implement as described in the preceding paragraph, the active species include at least one of a whitening agent, an enamel modifier, a mal-odor inhibitor, or an anti-bacterial.

In one or more additional aspects, in an oral care implement as described in the preceding paragraph, the cleaning element is movable relative to the cavity, the movable cleaning element and the cavity define a volume, and the movement of the movable cleaning element varies the volume.

In one or more additional aspects, in an oral care implement as described in the preceding paragraph, a channel fluidly connects the volume with an exterior of the head, and varying the volume causes selective ingress and egress of material into and out of the volume through the channel.

In one or more additional aspects, in an oral care implement as described in any of the preceding paragraphs, a valve regulates the ingress and egress of material into and out of the volume through the channel.

In one or more additional aspects, in an oral care implement as described in any of the preceding paragraphs, the channel extends between the volume and an opening in the movable cleaning element.

In one or more additional aspects, in an oral care implement as described in any of the preceding paragraphs, at least one of the one or more electrically conducting elements comprises a coil disposed around a ferrite core.

In one or more additional aspects, in an oral care implement as described in any of the preceding paragraphs, the one or more electrically conducting elements comprise a plurality of electrically conducting elements spaced about a periphery of the cavity.

In one or more additional aspects, in an oral care implement as described in any of the preceding paragraphs, the



ferromagnetic member is movable along a plane extending between magnetic fields of the plurality of electrically conducting elements.

In one or more additional aspects, in an oral care implement as described in any of the preceding paragraphs, a controller may selectively apply the current to individual of the electrically conducting elements.

In another aspect of this disclosure, a method of treating an oral cavity providing a powered oral care implement comprising a head including a cavity, a cleaning element disposed to at least partially cover the cavity, and an electrically conducting element disposed in the cavity; and applying a current to the electrically conducting element to at least one of (1) impart a motion on the implement and (2) generate active oxygen species and/or therapeutic molecules.

In one or more additional aspects, in a method as described in the preceding paragraph, the cleaning element includes a ferromagnetic material, applying the current to the electrically conducting element moves the ferromagnetic member, and the movement of the ferromagnetic member varies a volume defined by the cavity and the cleaning element.

Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

FIG. 1 is a perspective view of an oral care implement, embodied as a toothbrush, according to an example implementation of this disclosure;

FIG. 2 is an exploded cross-sectional view of an example implementation of the toothbrush of FIG. 1, taken along section line A-A in FIG. 1;

FIG. 3 is a partial, exploded cross-sectional view of another example implementation of a toothbrush of FIG. 1, taken along section line A-A in FIG. 1;

FIG. 4A is a partial, exploded cross-sectional view of an example implementation of the toothbrush of FIG. 1, taken along section line A-A in FIG. 1;

FIGS. 4B-4F are schematic illustrations of an example method of operating the toothbrush illustrated in FIG. 4A;

FIG. 5 is a perspective view of an oral care implement, embodied as a toothbrush, according to another example implementation of this disclosure; and

FIGS. 6A and 6B are schematic illustrations of driving devices usable in the oral care implement of FIG. 5.

#### DETAILED DESCRIPTION

This description of presently preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

As used throughout, ranges are used as shorthand for describing each and every value that is within the range. Any value within the range can be selected as the terminus of the range. In addition, all references cited herein are hereby incorporated by referenced in their entireties. In the event of

a conflict in a definition in the present disclosure and that of a cited reference, the present disclosure controls.

This disclosure relates generally to powered oral care implements, and more particularly to powered implements, such as powered toothbrushes, with electrical components in a head of the implement. The following detailed description may generally refer to embodiments of the inventive powered implements in the context of a toothbrush, but the disclosure is not limited to toothbrushes; other oral care implements may also incorporate features of this disclosure. By way of non-limiting example, mouth guard-type oral care implements, which do not include a handle, are known, and aspects of this disclosure may be incorporated into such an implement.

FIG. 1 illustrates a toothbrush 100 according to a first implementation of this disclosure. The toothbrush 100 generally includes a handle 102, a head 104 disposed at the distal end of the handle 102, and a neck portion 106 generally disposed between the handle 102 and the head 104. As illustrated, the handle has a generally elongate shape, along a longitudinal axis. This disclosure is not limited to the shape and/or size of the toothbrush 100 illustrated in FIG. 1. In alternative implementations, one or more of the handle 102, head 104, and/or neck 106 may have different shapes, sizes, orientations, and/or the like. Additional features may also be incorporated into the toothbrush or disposed on the toothbrush.

In the embodiment illustrated in FIG. 1, the toothbrush 100 also includes a movable cleaning element 108 disposed on the head 104 to move relative to the head. The movable cleaning element 108 generally includes one or more tooth cleaning elements 110 disposed on a tooth cleaning element support 112. As used herein, the term “tooth cleaning elements” includes any type of structure that is commonly used or is suitable for use in providing oral health benefits (e.g., tooth cleaning, tooth polishing, tooth whitening, massaging, stimulating, etc.) by making intimate contact with portions of the teeth and/or gums. Such tooth cleaning elements include but are not limited to tufts of bristles that can be formed to have a number of different shapes and sizes, massage elements, and elastomeric cleaning members that can be formed to have a number of different shapes and sizes, or a combination of both tufts of bristles and elastomeric cleaning members. The tooth cleaning elements 110 may be arranged on the tooth cleaning element support 112 in many configurations.

In FIG. 1, the tooth cleaning elements 110 include bristles, which may be formed as bristle tufts. The tufts may be formed with bristles of the same or different bristle materials (such as nylon bristles, spiral bristles, rubber bristles, etc.). Moreover, while the tooth cleaning elements 110 may be arranged so that they are generally perpendicular to a top surface 114 of the tooth cleaning element support 112, some or all of the tooth cleaning elements may be angled at various angles with respect to the top surface 114. When the top surface 114 includes bristle tufts, it is thereby possible to select the combination of bristle configurations, bristle materials and/or bristle orientations to achieve specific intended results and operational characteristics, thus maximizing and enhancing cleaning, tooth polishing, tooth whitening, massaging, stimulation, and the like.

The tooth cleaning elements 110 may be attached to the tooth cleaning element support 112 by any conventional method. In certain embodiments, the tooth cleaning element support 112 may comprise a head plate having a plurality of holes formed there through, and the tooth cleaning elements may be mounted to the head plate within the holes. This type



## 5

of technique for mounting the tooth cleaning elements to a head plate as the tooth cleaning element support **112** is generally known as anchor free tufting (AFT). In AFT a head plate or membrane is created and the tooth cleaning elements (such as bristles, elastomeric elements, and combinations thereof) are positioned into the head plate so as to extend through the holes of the head plate. The free ends of the tooth cleaning elements on one side of the head plate perform the cleaning function. The ends of the tooth cleaning elements on the other side of the head plate are melted together by heat to be anchored in place. As the tooth cleaning elements are melted together, a melt matte is formed, which is a layer of plastic formed from the collective ends of the tooth cleaning elements that connects the tooth cleaning elements to one another on one side of the head plate and prevents the tooth cleaning elements from being pulled through the tuft holes.

In some conventional designs, such as some conventional manual toothbrushes, after the tooth cleaning elements are secured to the head plate, the head plate may be secured to the head **104**, such as by ultrasonic welding. When the head plate is coupled to the head **104**, the melt matte is located between a lower surface of the head plate and a floor of a basin or cavity of the head **104** in which the head plate is disposed. The melt matte, which is coupled directly to and in fact forms a part of the tooth cleaning elements, prevents the tooth cleaning elements from being pulled through the holes in the head plate thus ensuring that the tooth cleaning elements remain attached to the head plate during use of the oral care implement.

In the illustrated embodiment, however, the head plate is not fixed to the head **104**. Instead, the head plate comprises a portion of the movable cleaning element **108** disposed to move relative to the remainder of the head **104**, neck **106**, and handle **102**.

In another embodiment, the tooth cleaning elements may be connected to a head plate or membrane later incorporated into the moveable cleaning element **108** using a technique known in the art as AMR. In this technique, a head plate is provided and the bristles are inserted into holes in the head plate so that free/cleaning ends of the bristles extend from the front surface of the head plate and bottom ends of the bristles are adjacent to the rear surface of the head plate. After the bristles are inserted into the holes in the head plate, the bottom ends of the bristles are melted together by applying heat thereto, thereby forming a melt matte at the rear surface of the head plate. The melt matte is a thin layer of plastic that is formed by melting the bottom ends of the bristles so that the bottom ends of the bristles transition into a liquid, at which point the liquid of the bottom ends of the bristles combine together into a single layer of liquid plastic that at least partially covers the rear surface of the head plate. After the heat is no longer applied, the melted bottom ends of the bristles solidify/harden to form the melt matte/thin layer of plastic. In some conventional applications, after formation of the melt matte, a tissue cleaner is injection molded onto the rear surface of the head plate, thereby trapping the melt matte between the tissue cleaner and the rear surface of the head plate. Other structures may be coupled to the rear surface of the head plate to trap the melt matte between the rear surface of the head plate and such structure without the structure necessarily being a tissue cleaner. For example, in embodiments of this disclosure, a structure covering the melt matte may be a plastic material that is used to form a smooth rear surface of the head, or the like. In still other embodiments, the structure can be molded

## 6

onto the rear surface of the head plate or snap-fit (or other mechanical coupling) to the rear surface of the head plate as desired.

Of course, techniques other than AFT and AMR can be used for mounting tooth cleaning elements to the tooth cleaning element support **112**, such as widely known and used stapling/anchoring techniques or the like. In such embodiments the tooth cleaning elements may be coupled directly to the tooth cleaning element support **112**. Furthermore, in a modified version of the AFT process discussed above, the head plate may be formed by positioning the tooth cleaning elements within a mold, and then molding the head plate around the tooth cleaning elements via an injection molding process. However, it should be appreciated that certain of the bristle tufts disclosed herein may not be adequately secured to the head using staple techniques, and one of AFT or AMR may therefore be preferred for securing such bristle tufts to the support **112**.

Moreover, in certain embodiments, the invention can be practiced with various combinations of stapled, IMT, AMR, or AFT cleaning elements. Alternatively, the tooth cleaning elements could be mounted to tuft blocks or sections by extending through suitable openings in the tuft blocks so that the base of the tooth cleaning elements is mounted within or below the tuft block. In still other embodiments, likely in which the tooth cleaning elements are not bristles, the tooth cleaning elements may be molded integrally with the tooth cleaning element support **112**.

A plurality of apertures **116** is also illustrated in FIG. 1. The apertures **116** are disposed through the tooth cleaning element support **112** and provide a channel or passageway through the tooth cleaning element support. Such a channel may allow for fluid communication between an inner cavity of the toothbrush **100**. The cavity, which may be bounded by the tooth cleaning element support and the head **104**, will be discussed in more detail below.

In embodiments of this disclosure, the movable cleaning element **108** may be moved relative to the head by an actuator disposed in the head. The actuator may also be selected to provide an electrical field in the head **104**. The electrical field may be useful to provide oral health benefits in addition to the benefits obtained by use of the tooth cleaning elements **110**. The actuator may be controlled, at least in part, by a user operating the toothbrush **100**. For example, a user interface **118**, embodied as a power switch, is provided on the handle **102**.

FIG. 2 shows an exploded, cross-section of a toothbrush **200**. The toothbrush **200** is an example implementation of the toothbrush **100**. As illustrated, the head **104** of toothbrush **200** includes a cavity **202**. The cavity **202** is a basin or void defined by a sidewall **204** that extends upwardly from a base **206** of the head **104**. One or more (two are shown) electrically conducting elements **208** are disposed in the cavity **202**. The electrically conducting elements may be any known shape or configuration, in addition to the configurations described in the examples herein. In some implementations, the electrically conducting elements **208** may be formed as electrical coils and include a number of turns of a metallic wire. In the illustrated embodiment each of the electrically conducting elements **208** includes such a winding, disposed about a core **210**, which may be a ferrite core. Electrical or conductive leads **212** connect each of the electrodes **208** to a power source **214**. In the illustrated embodiment, the power source **214** is a plurality of batteries disposed in the handle **102** and the leads **212** extend from the coils **208** through the neck **106** and into the handle **102** via a passageway or channel connected to the cavity **202** of the



head **104**. In some embodiments the batteries may be replaced with some other power source, and the power source may be rechargeable.

Application of current to the electrically conducting elements **208** creates an electrical field and a magnetic field generally along an axis of the electrodes **208** and, when present, the ferrite core **210**. A controller and/or additional electronics **216** may also be provided. For example, the controller **216** may selectively allow current from the power source **214** to the electrically conducting elements **208**. In some embodiments, the controller may alternate the current through the electrodes **208** and/or otherwise control the current, such as through pulse width modulation or alternating the current through the coils, to achieve desired activation sequences of the electrically conducting elements **208**.

In FIG. 2, the movable cleaning element **108** also includes one or more (two are illustrated) ferromagnetic members **218** depending from a bottom surface **220** of the tooth cleaning element support **112**, i.e., in a direction away from the tooth cleaning elements **110**. The ferromagnetic members **218** may be permanent magnets, electromagnets, or any other material or structure that may be repelled and/or attracted by a magnetic field.

The movable cleaning element **108** is positioned relative to the head **104** to cover the cavity **202**, and such that each of the ferromagnetic members **208** is arranged proximate one of the electrically conducting elements **208**. In this example, selectively energizing the elements **208** will selectively attract or repel the counter magnets **116**, resulting in movement of the movable cleaning element **108** relative to the remainder of the toothbrush **200**. As should be appreciated, in the embodiment illustrated in FIG. 2, the counter magnets will generally move along an axis of the ferrite core, i.e., normal to the top surface **114** of the moveable element **108**. In some embodiments, the controller may be programmed with one or more energizing sequences to effectuate one or more preferred vibrational patterns of the movable element **108**. For example, current to the elements **208** may be alternated to alternately attract and repel the moveable cleaning element **108**.

Although the movable cleaning element **108** is movable relative to the electrically conducting elements **208**, the movable cleaning element **108** is retained on the head **104**. Such retention preferably allows for the movable cleaning element **108** to move relative to the coils **208**, without becoming detached from the head. For example, FIG. 2 shows a protuberance **222** at a distal end of the sidewall **204**. Also, an inward projecting flange **224** is provided on the movable cleaning element **108**, spaced from the bottom surface **220** of the tooth cleaning element support by a leg **226**. In this embodiment, the movable cleaning element **108** is snapped onto the head **104** by passing the flange **224** downward over the protuberance **222**. Once engaged, the protuberance **222** prevents ready removal of the movable cleaning element **108**, but the movable cleaning element is capable of up-and-down movement. The movement is generally defined by a length of travel roughly approximate to a length of the leg **224** between the bottom surface **220** of the tooth cleaning element support **112** and the flange **224**.

In the illustrated example, the up-and-down movement of the movable cleaning element **108** will result in an increase and decrease of the volume described above.

Structures that include mating features other than the protuberance **222** in the flange **224** will be appreciated by

those with ordinary skill in the art having the benefit of this disclosure. Such alternative meeting features are within the scope of this disclosure.

Also in the embodiment of FIG. 2, the electrical conducting elements **208** may act as first and second electrodes, specifically, as an anode and a cathode. Controlling a current flowing between the first and second electrodes may be used to promote additional oral health benefits, to supplement the actions of the tooth cleaning elements **110**. For example, the electrodes may interact with specific ingredients in a dentifrice slurry by converting relatively stable precursors in the dentifrice to active oxygen species and other therapeutic molecules. By way of non-limiting example, a slurry may be acted upon by the electrodes to generate oxidizing agents, such as  $\text{Cl}_2$ ,  $\text{OCl}^-$ , and/or  $\text{HOCl}$ . In still other examples, the electrodes may be used to generate directly beneficial agents. For example, when one of the electrodes is made of zinc, selective energizing of the electrodes can generate different  $\text{Zn}^{2+}$  species, which are effective anti-bacterial agents. In further examples still, the electrodes may be used to promote tooth-uptake of fluorine. The electrodes may also be used to suppress or mask breath or mouth malodor.

Thus, the electrical conducting elements **208** may act as both an electromagnet, e.g., to promote actuation, and electrodes, e.g., to produce an electro-chemical effect. More specifically, both a magnetic field and electrical field generated by the electrical conducting elements may be useful in embodiments of the disclosure. In other embodiments, the elements may promote only actuation or only the electro-chemical effect. In still other embodiments, a plurality of electrodes may be provided that each performs one or more functions. In still another embodiment, it may be possible for the coil or surface to act as a catalyst without an applied electrical bias.

In some of the foregoing examples or other examples, particularly in embodiments where the electrical conducting elements **208** include electrodes, it may be desirable to allow for passage of fluids and the like from a position proximate the electrodes to a position in the oral cavity, such as in contact with a tooth. The apertures **116** may provide a flow path for this purpose. In one example embodiment, a slurry may be provided in the toothbrush, such as by being placed in the cavity **202** at the time of manufacture, which includes a relatively stable precursor, such as  $\text{HCl}$  acid. As the precursor is acted upon by the electrodes,  $\text{Cl}_2$ , an effective whitening agent, may be generated in the cavity **202**. The  $\text{Cl}_2$  may then exit the cavity **202**, and enter the oral cavity, via the apertures **16**. In some examples, flow may also be induced by changing the volume of the cavity **202**. More specifically, a volume may be defined by the cavity **202** and the movable cleaning element **108**, and movement of the moveable cleaning element **108** relative to the cavity **202** may expand or compress that volume. Increasing the volume will result in fluid flow into the volume, whereas decreasing the volume will expel fluid from the volume. Of course, this is but one example, and others will be apparent to those having ordinary skill in the art, with the benefit of this disclosure.

FIG. 3 illustrates a toothbrush **300** that is another example implementation of the toothbrush **100**. The toothbrush **300** is similar to the toothbrush **200** in many respects. For example, as illustrated, the head **104** includes a cavity **302**. The cavity **302** is a basin or void defined by a sidewall **304** extending upwardly from a base **306** of the head **104**. Instead of two windings, however, the embodiment of FIG. 3 has only a single winding as an electrical conducting element **308**. The winding **308** is arranged substantially normal



relative to the elements **208** of the toothbrush **200**, generally parallel to a longitudinal axis of the toothbrush **200**.

In the embodiment of FIG. 3, the movable cleaning element **108** includes a ferromagnetic member **310** disposed below a bottom surface **312** of the tooth cleaning element support **112**. In this embodiment, the ferromagnetic member **310** is fixed relative to the tooth cleaning element support **112**, and is configured to be received within the winding **308**. For example, in the illustrated embodiment, an arm **314** extends from the bottom surface **312** of the tooth cleaning element support **112**, and is fixed to a distal end of the ferromagnetic member **310**. In this arrangement, passing a current through the winding **308** will cause the ferromagnetic member **310**, and thus the movable cleaning element **108**, to move axially within the winding **308**. As will be appreciated, like the embodiment illustrated in FIG. 2, the current can be controlled to create pre-determined vibratory sequences of the movable cleaning element **108**. Also in the embodiment of FIG. 3, applying a current to the winding **308** may promote a chemical reaction, such as those discussed above.

The embodiment of FIGS. 2 and 3 each provide for linear movement of the movable cleaning element **108**. In each example, the movement is along a longitudinal axis of the respective winding comprising the electrically conducting elements **208**, **308**. FIG. 4A shows an alternative embodiment, which may provide a greater range of motion. FIGS. 4B-4F, described in more detail below, illustrate an example of this greater range of motion.

FIG. 4A illustrates a toothbrush **400**, which is an alternative implementation of the toothbrush of FIG. 1. The head **104** of the toothbrush **400** includes a cavity **402**. The cavity **402** is a basin or void defined by a sidewall **404** extending upwardly from a base **406** of the head **104**. A plurality of electrical windings as electrically conducting elements **408** are disposed in the cavity **402**, spaced about a periphery of the cavity **402**. The movable cleaning element **108** includes a ferromagnetic member **410** extending from a bottom surface **412** of the tooth cleaning element support **112**.

As with previously described examples, the windings act as electromagnets and electrical leads from a power source are disposed to selectively provide current to activate each of the windings **408**. In use, the ferromagnetic member **410** may be attracted to or repelled by the activated winding(s) **408**. By varying the order of activation, different motions of the tooth cleaning elements **110** may be achieved.

FIGS. 4B-4F provide a series of time-ordered schematic, top-view illustrations of depicting an example movement pattern, an elliptical motion, that may be achieved using the toothbrush **400**. In FIGS. 4B-4F the windings **408** include eight windings **408a-408h**. Those Figures also include a representation of the sidewall **404** and the ferromagnetic member **410**. All other features have been removed for clarity.

In FIG. 4B, the winding **408d** is activated, and the counter magnet is attracted to the winding **408d**. Next, in FIG. 4C, the winding **408d** is de-activated, and the windings **408e**, **408f** are activated. The ferromagnetic member **410** then moves toward the activating windings **408e**, **408f**, away from the now de-activated winding **408d**. Similarly, in FIG. 4D, windings **408e**, **408f** are de-activated, while windings **408g**, **408h** are activated. Again, the ferromagnetic member **410** moves toward the activated windings **408g**, **408h** and away from the de-activated windings **408e**, **408f**. FIGS. 4E and 4F are similar, with windings **408a**, **408b** being activated in FIG. 4E and windings **408c**, **408d** being activated in FIG. 4F. Although motion of the ferromagnetic member

**410** is discussed as resulting from an attraction to the activated winding, repulsion, or a combination of attraction and repulsion, may also be used.

The activation arrangement illustrated by FIGS. 4B-4F results in a clockwise rotation of the ferromagnetic member **410** (and thus of the tooth cleaning elements **110**) among the spaced windings. This is but one example motion profile, however. As will be appreciated, the windings **408a-408h** may be selectively activated in other profiles, to create any desirable cleaning pattern. By way of non-limiting example, the counter magnet **306** may be acted upon to move laterally, e.g., by alternately activating winding **408b** (or windings **408a**, **408b**, **408c**) and winding **408f** (or windings **408e**, **408f**, **408g**). In yet another embodiment, the windings **408a-408h** may be selectively activated to effectuate an axial movement of the movable cleaning element **108** similar to the movement described above for the toothbrush **300**, shown in FIG. 3. In this example, the wirings **408d** and **408h** may be alternately activated to effectuate a linear motion of the ferromagnetic member **410** between those windings.

FIG. 5 illustrates a toothbrush **500** according to another implementation of this disclosure. The toothbrush **500** includes a head **104** that defines a cavity **502**, similar to the cavities discussed above. A pair of electrodes **504** and an actuator **506** are disposed in the cavity **502**.

The electrodes **504** are disposed on either side of a longitudinal axis **512** extending generally along the handle of the toothbrush. Each of the electrodes **504** includes a pair of posts **508** spaced from each other and a wire **510** wrapped around the two posts **508**. The wire **510** of each of the electrodes **504** is connected to a power source, which is controlled to selectively energize the electrodes **504**, for example, to induce an electrochemical or chemical reaction in the head **104**. In the example, two electrodes are shown in FIG. 5, each spaced from the other and defined by a wire **510** wrapped around the posts **508** on the respective side of the longitudinal axis **512** with portions of the wire **510** spanning between the posts **508** parallel to the longitudinal axis **512**. In use, the two electrodes may act as an anode and a cathode. More or fewer electrodes may also be used. In other examples, each wire **510** may be wrapped about the posts **508** on respective sides of the longitudinal axis **512** in a woven or crisscross fashion (not shown) such that portions of the wire **510** spanning between the posts **508** cross one another and extend non-parallel to the longitudinal axis **512**. It is also contemplated, for example, that the electrodes **504** could be defined by wires **510** extending transversely between posts **508** on opposite sides of the longitudinal axis **512** (not shown).

The actuator **506** is positioned generally along, i.e., parallel to, the longitudinal axis **512**. The actuator **506** includes a movable element, movable relative to the head **104**, and the movement imparts a motion on the head **104**. In this example, although not illustrated, the toothbrush **500** will also include a cleaning element **108** that is arranged to cover or otherwise close the cavity **502**. Unlike in previous embodiments, however, where the cleaning element **108** moves relative to the head **104**, in this example, the cleaning element **108** may be fixed to the head **104**. The movement of the movable portion of the actuator imparts a movement on the entire toothbrush **500**, including the head **104**.

Although the cleaning element **108** may be disposed to occlude the cavity **502**, a plurality of apertures **512** is also illustrated in FIG. 5. The apertures **512** may provide a passageway through which fluid or the like can be exchanged between the oral cavity and the cavity **502**. In some implementations, a valve or the like (not illustrated)



## 11

may be provided in the apertures to restrict or otherwise control flow between the cavity **502** and the oral cavity.

FIGS. **6A** and **6B** illustrate embodiments of the actuator **506**. In those figures, the actuator **506** includes an electromagnet **602**, a movable element **604** movable by the electromagnet **602**, and a biasing member **606a**, **606b**. The actuator **506** is arranged generally along a longitudinal axis **608**, e.g., such that the movable element moves along the axis **608**. When incorporated in the toothbrush **500**, the longitudinal axis **608** of the actuator **506** may be arranged substantially parallel to the axis **512** as in FIG. **5**, although such is not required. In other implementations, the actuator may be arranged at an angle relative to the axis **512**.

The electromagnet **602** includes a wire **610** disposed around a ferrite core **612**. Selectively applying current to the wire **610** energizes the electromagnet **602** to form a magnetic field that may repel or attract the movable element **604**. In the illustrations, the movable member **604** is a permanent magnet having a north pole and a south pole spaced along the longitudinal axis **608**. In the embodiments shown in FIGS. **6A** and **6B**, the end of the electromagnet **602** proximate the movable member **604** may be a south pole when current is applied to the wire **610**. Accordingly, energizing the coil will repel the moveable element **604** away from the electromagnet **602** and toward the biasing member **606a**, **606b**.

The biasing member **606a**, **606b** is disposed to bias the moveable element **604** toward the electromagnet **602**. In FIG. **6A**, the biasing member **606a** is a stationary permanent magnet, having opposing north and south poles. When the north pole of the biasing member **606a** is arranged proximate the north pole of the movable element **604**, as in the figure, the movable element **604** repelled by the biasing member back to the electromagnet **602**. FIG. **6B** performs substantially the same function, e.g., to bias the moveable element **604** toward the electromagnet **602**, but biasing member **606b** is a spring, such as a coil spring. Other biasing members may also be used. For example, another electromagnet, such as the electromagnet **602** may be used as the biasing member. In still other embodiments, the biasing member may function more as a hard stop, with the field of the electromagnet being altered to attract the moveable member, back to the electromagnet.

In operation, the moveable element oscillates along the longitudinal axis **608**. Energizing the electromagnet forces the movable element **604** toward the biasing member, and, in the examples of FIGS. **6A** and **6B**, the biasing member returns the movable element toward the electromagnet **602**. The electromagnet **602**, the movable element **604**, and the biasing member **606a**, **606b**, may be retained in a housing **614**. For example, the housing **614** may be configured to retain the components in appropriate alignment and constrain the movement of the moveable element **604** between the electromagnet **602** and the biasing member **606**. In this example, the housing **614** is fixed in the cavity **502**, such as on a floor of the cavity. When the moveable element oscillates as described above, movement will be imparted on the entire toothbrush **500**.

In the embodiment of FIG. **5**, both the electromagnet **602** and the electrodes **504** are electrically conducting members. The actuator **506** is provided to impart a movement or vibratory effect on the toothbrush **500**, whereas the electrodes **504** may be provided to promote a chemical or electrochemical response. For example, and as described above, the wires **510** of the electrodes **504** may be made of zinc and applying a current the electrodes **504** may give off zinc ions. The electrodes **504** (as well as the electrodes

## 12

discussed in other embodiments) may be formed from any suitable orally-acceptable metal or electrically conductive material, including for example but not limited to zinc, nickel, iron, stainless steel, and blends thereof, or other suitable materials, and are not limited to the wound coils illustrated in the Figures. In other embodiments, the electrodes may include flat electrodes, mesh electrodes, porous electrodes, and the like.

As noted above, different movement or vibration patterns may be desirable. For example, different vibration patterns, oscillation speeds, and durations of those patterns may be more effective at cleaning different portions of the oral cavity. Moreover, certain movement patterns may promote fluid flow between the cavity **202**, **302**, **402**, **502** and the oral cavity, when such is desirable. Accordingly, for each of the embodiments described herein, it may be desirable to program different motion profiles into a controller, such as the controller **216**. For example, one or more profiles may correspond to one or more oral locations. In some embodiments, the controller may cycle through a plurality of the motion profiles based on a predetermined cleaning routine. A timer may also be used to start and/or stop different motion profiles.

In still other embodiments, the controller may receive a signal to commence (or end) a motion profile. The signal may be generated by the user, for example through interaction with a user input on the toothbrush, such as the input(s) **116**. In still other embodiments, one or more sensors may be provided on the toothbrush to create the signal that selects a motion profile. Examples of such sensors may include a strain sensor located on the toothbrush, e.g., on the neck of the toothbrush, one or more positional sensors, or some other sensor that can aid in deducing a specific oral location.

Modifications to the foregoing embodiments are contemplated. For example, configurations and the number of coils used may be varied. Moreover, although not illustrated herein, in certain embodiments the head **104** may also include a soft tissue cleanser coupled to or positioned on its rear surface. An example of a suitable soft tissue cleanser that may be used with the present invention and positioned on the rear surface of the head **104** is disclosed in U.S. Pat. No. 7,143,462, issued Dec. 5, 2006 to the assignee of the present application, the entirety of which is hereby incorporated by reference. In certain other embodiments, the soft tissue cleanser may include protuberances, which can take the form of one or more ridges (elongated transverse, longitudinal, angled), nubs, or combinations thereof. Of course, the invention is not to be so limited and in certain embodiments the oral care implement **100** may not include any soft tissue cleanser.

Although example embodiments have been described in language specific to the structural features and/or methodological acts, the claims are not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as illustrative forms of implementing the example embodiments.

What is claimed is:

1. An oral care implement comprising:
  - a head comprising a longitudinal axis and a cavity;
  - a first electrode positioned in the cavity and located on a first side of the longitudinal axis;
  - a second electrode positioned in the cavity and located on a second side of the longitudinal axis;
  - an actuator located in the cavity between the first and second electrodes, the actuator comprising:
    - an electromagnet;



13

a movable element that is movable by the electromagnet; and  
 a biasing member configured to bias the movable element towards the electromagnet; and  
 a cleaning element support member having cleaning elements thereon, the cleaning element support member coupled to the head to close the cavity, and wherein movement of the movable element of the actuator imparts a movement or vibration to the cleaning element support member.

2. The oral care implement according to claim 1 wherein the actuator is located along the longitudinal axis of the head and the movable element moves back-and-forth along the longitudinal axis.

3. The oral care implement according to claim 1 wherein the biasing member is a stationary permanent magnet having a north pole and a south pole and the movable element is a permanent magnet having a north pole and a south pole, wherein the biasing member and the movable element are arranged so that either the south poles or the north poles of the movable element and the biasing member face one another so that the biasing member repels the movable element towards the electromagnet.

14

4. The oral care implement according to claim 1 wherein the biasing member is a spring.

5. The oral care implement according to claim 1 wherein the electromagnet, the biasing member, and the movable element are positioned within a housing that is located within the cavity of the head, the movable element being located between the electromagnet and the biasing member and the housing constraining movement of the movable member between the electromagnet and the biasing member.

6. The oral care implement according to claim 5 wherein the electromagnet comprises a wire disposed around a ferrite core, and wherein applying current to the wire energizes the electromagnet to form a magnetic field that repels the movable element away from the electromagnet and towards the biasing member.

7. The oral care implement according to claim 1 wherein at least one of the first and second electrodes is made of zinc, and wherein applying a current to the one of the first and second electrodes causes the one of the first and second electrodes to release zinc ions.

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